New Millennium Program
Program Plan

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1.0 INTRODUCTION AND PROGRAM OVERVIEW

1.1 Introduction

The New Millennium Program (NMP) was formulated following National Aeronautics and Space Administration (NASA) management guidelines for the Program, dated June 12, 1995.[1] On July 30, 1996, the Associate Administrator for Space Science and the Acting Associate Administrator for Mission to Planet Earth designated the Jet Propulsion Laboratory (JPL) as the Lead Center for the NMP.[2] These original guidelines were incorporated into a NASA Headquarters-approved NMP Program Plan, dated July 8, 1997.[3]

Several key events affecting technology development and program management occurred since the formulation of the NMP. These include:

- The implementation of NASA Procedures and Guidelines (NPG) 7120.5A, NASA Program and Project Management Processes and Requirements, as a management standard.
- The organization of the Space Science Enterprise (SSE) into four science theme areas with challenging technology capability needs and the establishment of Earth Science Technology Office (ESTO) in the Earth Science Enterprise (ESE) to coordinate its technology planning.
- Significant changes in the project formulation process to re-focus the NMP projects towards technology validation with lower costs and frequent validation flight opportunities.

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[1]NASA, letter, Revised Management Guidelines for the Planned New Millennium Program. S/Associate Administrator for Technology Office of Space Science (M. Kicza); YT/Director, Office of Technology Innovation and System Integration, Office of Mission to Planet Earth (G. Paules); and XS/Director, Space Systems Division, Office of Space Assess and Technology (S. Venneri), June 1995.

[2]NASA, letter, Assignment of the Lead Center for the New Millennium Program (NMP). S/Associate Administrator for Space Science (W. Huntress); Y/Acting Associate Administrator for Mission to Planet Earth (W. Townsend), July 1996.

[3] NASA Jet Propulsion Laboratory, JPL D-13968, The New Millennium Program Plan. S/Associate Administrator for Space Science (E. Huckins), April 1997; Y/Associate Administrator for Mission to Planet Earth (W. Townsend), July 1997.

The changes described above were initiated in Fiscal Year 1999. They are incorporated into the NMP Formulation Authorization Document[4] a joint ESE and SSE Program Commitment Agreement (PCA),[5] and this revised Program Plan.

1.2 Overview

The NMP is a cross-enterprise technology program jointly funded and managed by the SSE and ESE. Its purpose is to develop and flight validate breakthrough technologies to retire risk for first use before they can significantly benefit future space science and Earth science missions. Both the SSE and ESE utilize the NMP as a primary path to flight validate key emerging technologies to enable exciting 21st century science missions.

The NMP projects may also return valuable science data to the extent possible within cost and other project constraints. The NMP will maximize the participation from industry, universities, and other government agencies to reach its objectives.

The technology validation flights are grouped into projects sponsored by the SSE and ESE. The first two technology projects to support the SSE were named Deep Space projects, and the rest are designated Space Technology projects. The technology projects to support ESE are Earth Observing (EO) projects.

This Program Plan implements the objectives and performance goals for the program-level requirements as specified in the NMP PCA. Project Level-1 Requirements (PLRs) for each NMP project are established by the funding Enterprise at project approval and are appended to this Program Plan after project approval.

1.2.1 Application

The requirements of this document shall apply to the NMP and its projects except for the EO-1 Project. As described in the NMP PCA, the EO-1 Project shall conform to the NMP PCA and maintain its separate Program Plan. The Governing Program Management Council (GPMC) for EO-1 shall be the GPMC at the Goddard Space Flight Center, and the GPMC at the JPL shall be the GPMC for the remainder of the NMP.

1.2.2 Precedence

The NMP PCA defines the agreement between the NASA Administrator and the Associate Administrators for Space Science and Earth Science for attainment of NMP objectives and Program commitments. The PCA conforms to NPG 7120.5 and invokes this document on NMP projects

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[4] NASA, Formulation Authorization New Millennium Program (NMP). S/Associate Administrator for Space Science (E. Weiler), November 1999; Y/Associate Administrator for Earth Science (G. Asrar), December 1999.

[5] NASA, New Millennium Program Program Commitment Agreement S/Associate Administrator for Space Science (E. Weiler); Y/Associate Administrator for Earth Science (G. Asrar); AE/Chief Engineer (In concurrence), June 2000.

except for EO-1. In the event of conflict between NPG 7120.5, the NMP PCA, and this document, the NPG 7120.5 and then the NMP PCA take precedence.

This Program Plan replaces and supersedes the previous NMP Plan.[3] In this Plan, the term "project" describes a package of technology validation activities that may also apply to a grouping of one or more subsystems for flight validation.

2.0 PROGRAM OBJECTIVES

The NMP PCA defines three primary objectives. They are:

- To identify and select technologies for flight validations that optimize the benefits to the SSE and ESE;
- To develop and implement effective flight projects that include technology development and flight validation as appropriate testbeds to mitigate the risks for using the selected technologies in science missions; and,
- To facilitate the infusion of the validated technologies into science mission opportunities.

Each project responds to all three NMP objectives. Table 2.0-1, NMP Technical Performance Commitments and Performance Indicators, relates the technical performance commitments in the NMP PCA to indicators that the NMP will use to determine acceptable performance to the PCA commitments. Because the NMP is an on-going program, the definition of the sequence and content of projects occurs in relation to the strategic plans of the respective enterprises.

The NMP projects are divided into two categories, system development/validation and subsystem development/validation. The categories differ in the roles of the technologies in the project. Each system project has breakthrough technologies that are divided into two sub-categories, project-defining and project-enhancing. Project-defining technologies are new technologies that replace proven technologies to perform critical functions in the flight project and whose successful operations are required for project success. Project-enhancing technologies are new technologies whose successful operations enhance the project, but they do not perform critical functions in the project. Subsystem projects contain only project-enhancing breakthrough technologies; that is, failure of a single technology in a subsystem flight validation does not compromise the successful validation of the remainder of the technologies in the project.

NMP PCA Technical Performance Commitments	NMP Performance Indicators
• Each project selected for formulation shall respond to at least one technology requirement in the ESE or SSE Strategic Plan. • The selection of the destination for each flight validation project shall be determined based upon the requirements for technology validation and is not driven by requirements for science data collection.	• The identified and selected technologies and their validation scenarios coincide with the requirements in the Enterprises' roadmaps. • Program processes result in Enterprise Associate Administrator's (EAA's) authorization for concept definition, down-selection of concepts and transition to formulation refinement, and approval for implementation on schedule.
• Technologies eligible for selection for a new project shall have completed technology development to a technology readiness level where the concept design has been tested experimentally. • Technologies selected for a project shall have completed testing of the pre-prototype prior to project approval and initiating project implementation. • Over a five-year running time period, a minimum of 70 percent of the approved project-defining technologies shall be flight validated, and 80 percent of the project-defining technologies that are launched in a project shall be flight validated. • Over a five-year running time period, a minimum of 70 percent of the approved project-enhancing technologies shall be flight validated.	• The PLRs include success criteria that are expressed as percentages of the project-defining and project-enhancing technologies that are successfully flight validated. • Scheduled Program and project reviews verify that progress in achieving planned milestones is on schedule and within resource constraints. • Flight validations of the selected technologies are completed before the start date of the implementation phase for the first science mission requiring the technology.

Table 2.0-1, NMP Technical Performance Commitments and Performance Indicators.

NMP PCA Technical Performance Commitments	NMP Performance Indicators
• Advances in technology development that occur prior to launch shall be documented in annual updates to the NASA Technology Inventory and in a report prepared and submitted by the NMP Office to the applicable Enterprise as part of the annual budget review. • Data from technology flight validations shall be documented and made available to technology providers and mission planners within six months of the completion of flight validation subject to the restrictions imposed by Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR).	• Results of technology validations for a project are disseminated to the science and technology community within six months of the completion of the flight data collection for technology validation. • The proceedings of a flight validation workshop are published within six months of the workshop.

Table 2.0-1. NMP Technical Performance Commitments and Performance Indicators (Continued)

3.0 CUSTOMER DEFINITION AND ADVOCACY

The NMP customers for NMP products, namely the flight validated technologies, are future SSE and ESE science missions.

The customer advocacy for NMP products is accomplished through the following activities:

- The coordinated planning and development of technology flight validation from lower readiness levels through flight validation;
- The alignment of flight validation objectives with future mission capability needs;
- Cost effective program execution;
- Communication with the science and technology community during formulation and implementation;
- Education and public outreach (E&PO); and,
- Effective communication of technology validation results.

4.0 PROGRAM AUTHORITY AND MANAGEMENT STRUCTURE

This section describes the overall structure of the NMP including authority, management structure, interfaces, and responsibilities of the NMP participating organizations for carrying out the NMP sub-processes.

4.1 Authority

The SSE and ESE share programmatic, scientific, and technical authority for the NMP. Their responsibilities, which are defined in the NMP PCA, are described in paragraph 4.3.1. As required in

the NMP PCA, the JPL is the lead center for NMP. Its responsibilities are described in paragraph 4.3.2. The GPMC for the NMP is the Program Management Council at JPL. The GPMC membership includes representation from the NMP projects' implementing centers.

4.2 Management Structure

4.2.1 Organization and Interfaces

The NMP organizational structure is illustrated in Figure 4.2.1-1. The SSE and the ESE share organizational responsibility for the NMP as described in paragraph 4.1 above. The JPL Director, as Lead Center Director, has delegated the day-to-day program management activities to JPL's Space and Earth Science Programs Directorate (SESPD). The NMP Manager and Program Office reside within the SESPD organization.

The NMP Chief Scientist interfaces with the science community and assists in the development of technology validation requirements and roadmaps. Program technologists from disciplines representing key NASA technology needs interact with the U.S. technology community on behalf of the NMP. They also lead technology planning, technology validation needs identification, and technology infusion.

Integrated Project Formulation Teams (IPFTs) define candidate technology validation concepts for the next NMP project. Their membership is comprised of NMP staff and technology providers for a project that are selected for each project concept via open peer reviewed technology solicitations. The IPFTs transition to NMP projects when the EAA down-selects them to begin Formulation Refinement. Staff from the project lead center replace NMP staff on the teams as part of the transition.

4.3 Responsibilities

4.3.1 Headquarters Responsibilities

The SSE and ESE shall have primary management responsibility for:

- Establishing the program's requirements, budget, and metrics;
- Establishing the priorities, constraints, and Headquarters-controlled PLRs;
- Reviewing Program and project performances against Program and project requirements, including technical, cost, and schedule commitments;
- Approving the NMP Program Plan and concurring on Project Plans;
- Approving technology validation needs;

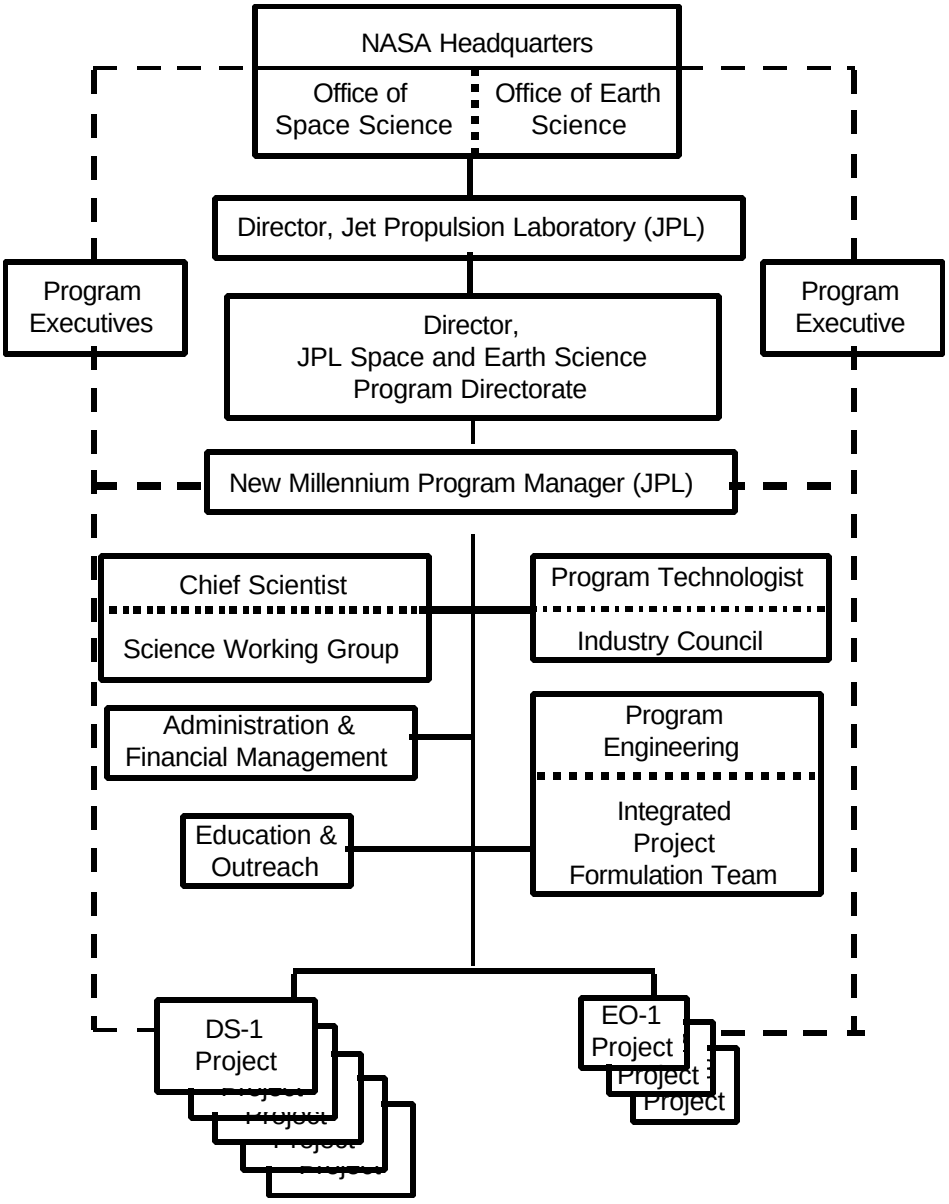

Figure 4.2.1-1. NMP Organizational Structure.

- Authorizing definitions of new project concepts;
- Overseeing the peer and selection reviews of competing technologies for flight validation concept candidates;
- Assigning the implementing centers for projects;
- Down-selecting competing project concepts;
- Issuing competitive procurements and awards for science where appropriate for the project;
- Reviewing and approving the projects;
- Maintaining external advocacy and coordination;

- Leading development and approval of agreements with other government agencies and international partners;
- Coordinating launch vehicle requests;
- Managing the NASA launch approval and environmental impact processes affecting the NMP; and,
- Requesting special purpose reviews (e.g., Termination Reviews).

4.3.2 Program Lead Center Responsibilities

4.3.2.1 Program Lead Center Director

The JPL Director shall be responsible for duties as defined in NMP 7120.5A, Appendix D.2, paragraph a. As noted in paragraph 4.2.1, he has delegated these responsibilities to the Director of the SESPD.

4.3.2.2 Program Office

The NMP Office at the JPL shall be responsible for the following:

- Conducting the solicitations and peer reviews of technology candidates for flight validation;
- Recommending technologies for flight validation pre-concepts;
- Managing the implementation of the NMP and its associated projects;
- Overseeing and reviewing progress of NMP projects;
- Reviewing and reporting Program and project performance;
- Developing technology validation roadmaps;
- Developing and maintaining an inventory of technology validation needs;
- Approving project plans and documentation except for the NMP PCA and PLRs;
- Implementing the project formulation process with NASA Headquarters oversight;
- Developing internal and external agreements for technology development partnering;
- Supporting NASA independent reviews;
- Assessing and making recommendations to resolve inadequacies in resources at the JPL and the NASA centers to support Program and project requirements;
- Coordinating cross-center activities;
- Coordinating with non-NMP technology development organizations and programs;
- Developing requirements for Program funding, facilities, and staffing that coincide with available funding, facilities, and staffing;
- Developing implementation plans;
- Managing Program planning;
- Developing project requirements and performance metrics that are traceable to and implement the requirements established at Headquarters;
- Developing technology infusion guidelines;
- Coordinating the NMP's inputs to technology databases and NASA's Technology Inventory;
- Recommending and requesting a NASA Headquarters' determination of applicability of the NMP Environmental Assessment
- Reporting NMP status to the SSE and ESE science advisory forums and science communities; and,

- Managing the Program E&PO activities and coordinating the implementation of the education and public outreach plans of the projects.

4.3.3 Responsibilities of the Implementing Center for an NMP Project

4.3.3.1 Project Implementing Center Director

The Center Director for the implementing center for an NMP project shall be responsible for the following:

- Approving the Project Plan;
- Appointing the Project Manager;
- Implementing and overseeing the project using the center's PMC;
- Developing and maintaining project implementation policies and procedures compliant with the NMP PCA and the NMP Program Plan; and,
- Designating Center representation to the NMP GPMC at JPL.

4.3.3.2 Project Manager

Each Project Manager shall be responsible for the overall success of the project and shall be accountable to the NMP Manager for achieving the PLRs and commitments in the NMP PCA applicable to the project. Accordingly, the Project Manager shall act as the single interface to the NMP Office in accomplishing the assigned project and shall be responsible for the following:

- Developing draft PLRs and proposing modifications to them as needed;
- Preparing, obtaining approval for, and executing the Project Plan;
- Forming the project team that includes the technology providers selected for the project during Concept Definition whose technologies were successfully incorporated into the project;
- Conducting mission and operations planning;
- Developing, designing, building, assembling, testing, launching and operating the engineering systems to meet the PLRs;
- Managing assigned resources (including safety and risk management);
- Reporting project performance and status monthly;
- Acquiring participating contractors and partners;
- Performing Safety and Mission Assurance;
- Reporting flight validation results;
- Supporting independent assessments (e.g., Program Confirmation Readiness Assessment (CRA) and a NASA Headquarters Confirmation Review (CR));
- Developing and implementing an education and public outreach activity for the project in conjunction with the NMP E&PO Manager;
- Certifying the project's flight readiness by letter through the NMP Office and the JPL GPMC;
- Providing summary reports on the level of success attained in developing and validating the project's technology;
- Delivering project technology validation data;
- Archiving project data; and,
- Completing project closeout.

4.4 Sub-Processes to Develop, Validate, and Infuse Technology

The NMP uses six sub-processes to formulate and implement technology development and validation projects and to infuse the results into future science missions. The six sub-processes (see Figure 4.4-1) are:

1. Identification of flight validation technology candidates;
2. Project concept definition;
3. Project formulation refinement;
4. Project approval;
5. Project implementation; and,
6. Technology validation and infusion.

Sub-process details are described in the following paragraphs.

4.4.1 Identification of Flight Validation Technology Candidates

The NMP engages the SSE theme technologists and ESTO to generate a list of capability needs for future NASA space and Earth science missions. They use the NASA Strategic Plan, capability requirements from the science strategic plans and SSE and ESE technology roadmaps to develop the list. The NMP develops a second list of technology availability based upon input it receives from NASA and non-NASA technology providers in the U.S. The second list contains technology that is available at the time the list is prepared as well as forecasted dates of availability in the next five years based upon current and project funding availability. It coordinates the content of the second list with the technologists, ESTO, and the technology providers, retaining items on the list when the available technology meets the capability needs, the technology requires flight validation, more than one mission needs the technology, and the time when the validated technology will be available matches the need date for the first science mission that needs the technology. The second list is defined as a NMP technology validation roadmap.

The NMP Office assigns each technology in the roadmap mission and a set of flight validation factors for risk reduction. These factors may include items such as operational environments or mission scenarios where the technology will be used and risks associated with shifts in the implementation approach. The project and Program Office also use the risks and factors to perform continuous risk assessment and control throughout the project's formulation and implementation. See paragraph 14.1 for the distinction between technology user risks and project implementation risks.

The NMP Office uses the roadmaps, risks, and associated risk reduction factors to develop candidate validation scenarios for each available technology and cost estimates for each scenario and presents this information to the applicable EAA. The EAA uses these factors as information to establish priorities and constraints for pre-concepts and to authorize concept definitions for

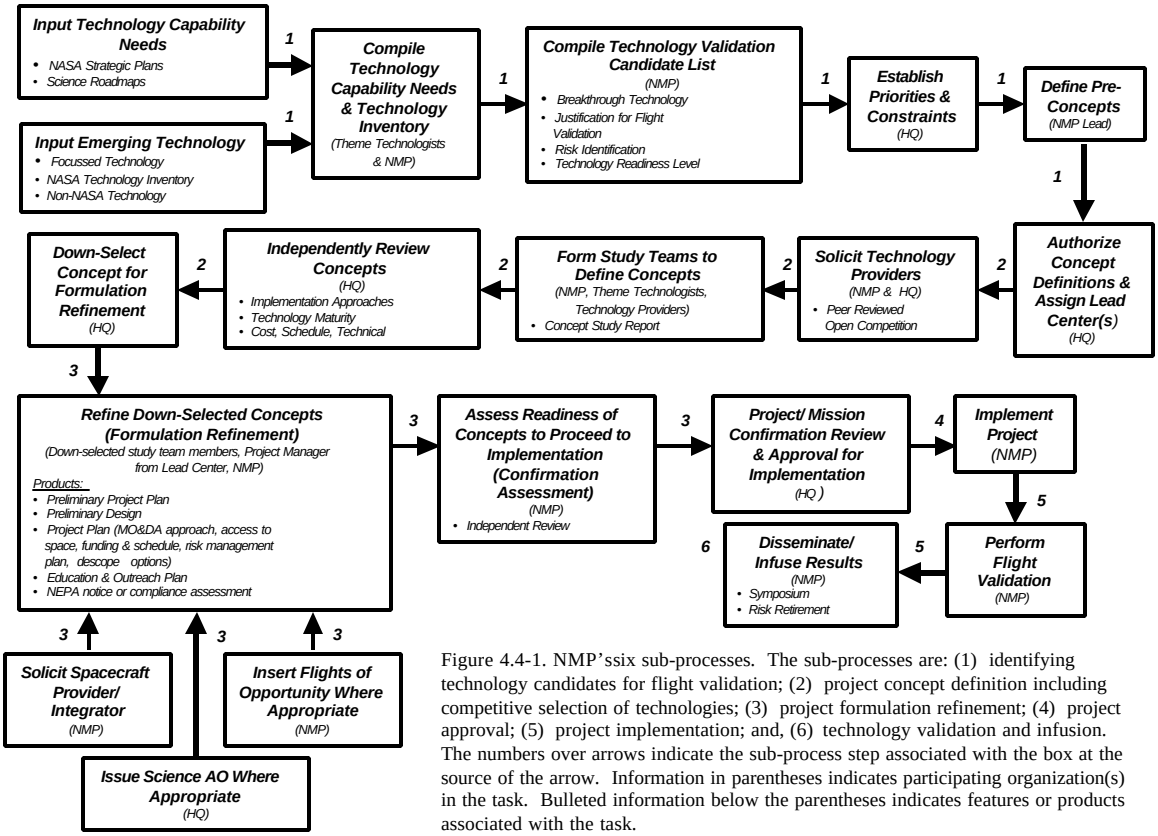

Figure 4.4-1. NMP'ssix sub-processes. The sub-processes are: (1) identifying technology candidates for flight validation; (2) project concept definition including competitive selection of technologies; (3) project formulation refinement; (4) project approval; (5) project implementation; and, (6) technology validation and infusion. The numbers over arrows indicate the sub-process step associated with the box at the source of the arrow. Information in parentheses indicates participating organization(s) in the task. Bulleted information below the parentheses indicates features or products associated with the task.

new projects. The priorities and constraints may include a determination of whether the next project will be sub-system or system validations, an identification of a subset of the technologies that have higher priorities for pre-concept definition than others, and cost or schedule constraints for completion of the new project.

If the EAA determines that the next project is a system validation, the NMP Office forms a team of technolgists for each technology in the subset establised by the EAA to develop a project pre-concept. The appropriate SSE theme or ESTO technologists, technology providers that agree not to compete to provide technology for the project, and the NMP technologists, Chief Scientist, and Architect participate on the team. The product of the teams's pre-concept definition is a report that includes a pre-concept definition and a set of technology requirements that supports the pre-concept. This product is used to solicit technology providers or innovative measurement concept providers in peer-reviewed open competition after the EAA authorizes concept definition.

If the EAA determines that the next project is a sub-system validation, the NMP Office forms a team of technologists for each technology in the subset with the same membership as that for a system validation pre-project. The product of the team's pre-concept definition is different from that for a system validation pre-project team. The report includes a set of technology requirements that supports the capability needs of the science customers and is used to solicit technology providers in peer-reviewed, open competition. However, it does not contain a definition of the flight validation scenario, because that is solicited as part of the competition for technology providers.

The NMP Office presents the team reports, the roadmaps, risks, factors for risk reduction, and estimated costs to the applicable EAA. The EAA uses this information to authorize a set of concept definitions. For the SSE, the EAA also designates a lead science theme or area for each member of the set and assigns a lead center for each member of the set providing at least one pre-concept is acceptable. For the ESE, the EAA assigns the lead center for each concept after selecting awardees from the NASA Research Announcemnt (NRA). If no pre-concepts are acceptable, the EAA directs the NMP Office to develop additional pre-concepts.

4.4.2 Project Concept Definition

The NMP PCA tailors the formulation phase as described in NPG 7120.5A by dividing it into two segments, Concept Definition and Formulation Refinement. This tailoring is reflected in Figure 4.4-1, and down-selection of concepts by the EAA divides the two segments.

After the EAA authorizes concept definition for a set of pre-concepts, the process for soliciting technology providers differs for the SSE and the ESE. The ESE uses a two-step solicitation, a Headquarters-led NRA to solicit innovative concepts for new Earth measurement capabilities followed by the NMP-issued technology announcement. The SSE uses a one-step solicitation, a NMP-issued technology announcement, because the SSE's technology capability needs do not generally focus on measurement capabilities.

For the ESE, the Program Executive and the NMP Office develop the NRA using the capability needs developed during the pre-concept definition and information from the ESE Strategic Plan.
The EAA issues the NRA to obtain proposals for new Earth science measurement capabilities that include breakthrough, enabling, and enhancing technologies. As with all NMP technology solicitations, the solicitation is open to technology providers from U.S. industry, universities, and government agencies. The ESE Program Executive leads the establishment of peer review panels and the EAA selects the awardees. The EAA assigns a lead center and designates a lead science area for each awardee. Each awardee leads a concept definition team. The NMP Office prepares a competitive solicitation for technology providers for each team using the system capability needs from the proposal and direction from the EAA given as part of the NRA awards. The ESE Program Executive oversees the selection of peer reviewers and peer review panels, and the establishment of the selection recommendation committee. Awardees are added as members of the concept definition team. Concept Definition begins after these awards.

For the SSE system validations, the NMP Office prepares a competitive solicitation for technology providers for each pre-concept using the technology capability needs from the pre-concept report and direction from the EAA given as part of the authorization for concept definition. The SSE Program Executive oversees the selection of peer reviewers, peer review panels, and the members of the selection recommendation committee. System validation awardees become members of one of the concept definition teams. Concept Definition begins after these awards.

For the SSE sub-system validations, the NMP Office prepares a competitive solicitation for proposals for technology providers and validation scenarios that meet the requirements for intended uses in science

missions using the priorities and constraints established by the EAA. Each sub-system awardee receives funding for technology development and definition of an independent project flight validation concept.

For system validations, each team defines a concept, incorporating as many of the selected technologies as possible within the resource constraints defined as part of the authorization for concept definition. The NMP Office provides funding for development of the concept, trade studies to support a plan for risk retirement, a validation approach, and integrated mission design studies. The NMP Architect works with each team to ensure that the reports and concept definition meet the requirements of the NMP PCA and NPG 7120.5A.

Using guidelines issued by the NMP Office, each team or sub-system technology prepares a report that includes the concept definition, a management plan, and a cost plan. When the report is completed, it is submitted to the implementing center PMC for review before submittal to the NMP. The NMP Manager funds an independent cost review of each concept, and the results are provided to the EAA during down-selection.

The Enterprise Program Executive establishes an independent review team to assess the implementation approach, technology maturity, and feasibility of the cost, schedule, and technical content of each concept definition report. Members of the review team are science theme or science area technologists, technology providers, and scientists/customers from the lead science area. Their results are presented to the EAA at down-selection.

The EAA reviews all concept definitions, the results of the NMP-led independent cost review, and the Enterprise-led independent review and down-selects one or more concepts for Formulation Refinement. Pursuant to the ground rules established in the technology solicitations, technology providers whose technologies are incorporated into the down-selected concepts provide the flight articles without additional competition. Technology providers who do not satisfy these requirements are no longer part of an NMP project. The EAA issues a selection letter to each implementing center having a down-selected concept requesting a center commitment to the project. This selection includes technologies to be validated, the approach for validation (including the destination), the management approach, and resource constraints. The center's positive response transitions the project from concept definition to formulation refinement, and transitions the project from being led by the NMP Office to being led by the implementing center. At this juncture, the role of the NMP Office changes to project oversight.

4.4.3 Project Formulation Refinement

At the beginning of Formulation Refinement, the implementing center identifies the Project Manager and staffs the project team. The implementing center establishes contracts with the technology providers whose technologies are incorporated into the concept, and the technology providers are added to the project team (see paragraph 10, Acquisition Strategy). If science is identified and authorized as part of the concept during down-selection, the NMP Office and project team work with the Enterprise Program Executive to develop a NASA Announcement of Opportunity that is issued by the EAA, and science awardees are added to the project team. If the down-selected project includes a spacecraft provider or a spacecraft integrator, the implementing center issues a Request for Proposals to obtain

the provider/integrator, and the provider/integrator is added to the project team at the time of contract award. During this time, the NMP Office works with the project team to facilitate a smooth transition and to maintain traceability to the Program's requirements in the NMP PCA and the Program Plan.

The project team refines the concept by performing a preliminary design, developing the project documentation (see paragraph 5.1), and drafting agreements (see paragraph 9.0). The implementing center's PMC and the lead center GPMC review the progress in completing Formulation Refinement. At the conclusion of Formulation Refinement, the NMP Office performs a CRA to assess the readiness of the project concept to proceed to approval and implementation. This CRA is an independent review overseen by the NMP Office but performed by personnel not associated with the NMP. It reviews the preliminary design and all documentation required for project approval (see paragraph 5.2). Results of the CRA are presented to the implementing center's PMC and the NMP GPMC for concurrence before forwarding the project to the EAA for a Mission (for ESE) or project (for SSE) CR.

4.4.4 Project Approval

A positive recommendation from the GPMC to the EAA initiates a Mission Confirmation Review (MCR) for the ESE or a CR for the SSE. During the MCR or CR (hereafter referred to collectively as a CR), the EAA reviews the draft project plans and agreements, the results from the CRA, and the draft PLRs. The results of the review can have one of three outcomes: cancellation of the project, instructions to continue with Formulation Refinement, or approval for implementation. If the EAA approves the project for implementation, the PLRs are signed and appended to this plan, the project plan is approved, and draft agreements are finalized.

4.4.5 Project Implementation

Each NMP project shall implement its project in accordance with the requirements of NPG 7120.5A, section 3.3, this program plan including PLRs, the approved Project Plan, implementing center policies and procedures, and any EAA special instructions. During this phase, the NMP Office oversees project progress, and the implementing center PMC and GPMC review the progress as agents for the EAA. The Implementation Phase concludes after flight validation and technology infusion are concluded. Accordingly, the NMP and its projects shall perform implementation functions and activities as follows:

4.4.5.1 Project Control

- Ensure technology development and integration occur so that risks are understood and handled;
- Execute all approved plans;
- Execute, where appropriate, spacecraft provider, instrument provider, and technology provider contracts;
- Execute internal and external agreements;
- Maintain currency of reserves;
- Place documents in the master control documents list under configuration control; and,
- Update the Project Plan, as required.

4.4.5.2 Customer Advocacy

- Provide technology validation results in accordance with the Technology Validation and Infusion Plan

4.4.5.3 Requirements Management

- Implement the CM processes so that there is traceability of requirements to design and operations;
- Document changes to requirements following CM processes;
- Develop technology and determine readiness of technology for flight validation; and,
- Interact with the technology user community to verify agreement with the validation approach.

4.4.5.4 Design, Develop, and Sustain

- Execute the design, development, test, and verification of the technologies for flight validation;
- Perform risk management to ensure project cost and schedule commitments;
- Conduct project development, design, and sustaining activities in accordance with International Standards Organization (ISO) 9000 validated processes;
- Conduct design reviews as specified in the Project Plan;
- Deliver technology validation and products to the Agency and science community; and,
- Protect non-disclosure of intellectual property including requirements of the EAR and ITAR.

4.4.5.5 Deliver Products and Services

- Deliver the flight hardware and software and technologies for flight validation in accordance with the project's plans and commitments in the PLRs;
- Provide as-built documentation;
- Conduct end-to-end system-level readiness testing and support integrated program testing, as required;
- Generate the procedures for operation of the total project and for each technology in the project; and
- Launch the technology flight validation project.

4.4.5.6 Capture Process Knowledge

- Collect, analyze, and report technology validation results; and,
- Report and publish the results of the technology flight validation project.

4.4.6 Technology Validation and Infusion

The purpose of the NMP is to retire risk of first use of breakthrough technologies in order to accelerate the infusion of the technologies into future science missions. The users of the validated technologies are identified during the identification of flight validation candidates (paragraph 4.4.1). The NMP shall facilitate infusion by:

- Maintaining a NMP Guideline for Technology Validation and Infusion Planning to be used by the NMP projects;

- Interacting with the user community during the identification of technology candidates so that critical validation scenarios are identified and critical risks for first use in a science mission are retired;
- Keeping potential customers informed of progress throughout the project formulation and implementation; and,
- Disseminating validation results, advocating the benefits, and assisting users in the infusion of validated technologies into the future missions and mission planning.

Participants in infusion are the NMP project, the technology providers, the future science mission planners and scientists (users), and the NMP Office. The technologists within these organizations are the principals who are held accountable for ensuring that data from the technology developments and validations are continuously documented and effectively disseminated to the broad user community.

In accordance with the technical performance commitment in the NMP PCA, the NMP Office provides annual updates to the NASA Technology Inventory and annual progress reports and submits them to the applicable Enterprise as part of the annual budget review. The NMP shall incorporate advances in technology development that occur during project formulation and implementation and the results of technology validations into a technology readiness database. This database will be available for use in preparing competitive procurements in support of science missions or science instruments and other science mission planning activities.

Within six months of the completion of data collection for flight validation, the NMP Office shall host a workshop or symposium to disseminate the results of technology flight validation to the science and technology community. The project team shall present results of the technology developments and validations at this workshop or symposium. The NMP Office shall officially publish its final technology validation report subject to the restrictions imposed by the EAR and the ITAR.

5.0 PROGRAM REQUIREMENTS

The purpose of the NMP Office and this Program Plan is to implement the requirements of the NMP PCA for the SSE and ESE. The NMP Office performs the functions described in paragraph 4.3.2 and implements the process as described in paragraph 4.4.

5.1 Program Requirements for NMP Projects

Each NMP project shall perform the functions described in paragraph 4.3.3.2 and implement the processes as described in paragraph 4.4.3 through 4.4.6.

5.1.1 Project Level-1 Requirements

Each NMP project shall develop draft PLRs that are consistent with the NMP PCA and include the following as a minimum:

- Project objectives including traceability to the technology validation plan and project success criteria;
- Cost and schedule commitments;
- Internal and external agreements; and,
- Approach to safety and risk management.

The PLRs shall be appended to this document at project approval. Requests for changes to the PLRs are first reviewed by the implementing center PMC and then submitted through the NMP Office for review by the GPMC. Subsequently, the NMP Office then forwards the request with the PMC and GPMC recommendations to the EAA for disposition.

5.1.2 Project Plan

Each NMP project shall complete a draft Project Plan during Formulation Refinement and submit it as part of the documentation for CRA, CR, and project approval. The NMP Office shall approve the Project Plan at project approval. Changes to the plan shall be submitted to the NMP Office for approval using the NMP's Configuration Management Process (see paragraph 8.0). The Project Plan shall comply with the requirements of NPG 7120.5, Appendix E.4 and shall contain the following additional information:

- Cost reserves that are included within the project cost cap identified in the PLRs (see paragraph 14.4);
- Descope options to accommodate project risks;
- Margins to accommodate project risks;
- An integrated master schedule that includes the identification of the critical path to project success and scheduled reviews identified in paragraph 17.0,
- A system for configuration control;
- Performance metrics;
- A plan for risk management;
- A plan for information management that includes a Master Controlled Data List;
- A Technology Data Management Plan appended to the Project Plan (see paragraph 13.0 Data Management and Archive);
- A Science Data Management Plan appended to the Project Plan when project goals for science data acquisition are included in the PLRs (see paragraph 13.0);
- A Technology Validation and Infusion Plan appended to the Project Plan (see paragraph 5.1.2.1);
- A Measurement Concept Plan appended to the Project Plan when an Earth measurement experiment is included in the PLRs;
- An E&PO Plan;
- Program Plan requirements tailoring; and,
- A plan for project closeout.

5.1.2.1 Technology Validation and Infusion Plan

The Technology Validation and Infusion Plan shall include the following for each selected technology:

- A description of the technology including the nature of the technology breakthrough, future applications, risks to be retired, and target customer;
- Objectives of the technology development and validation;
- A technology developments plan including technology development to reach the readiness for flight validation, ground and flight test plans, and validations required to define a range for applicability so that the validated technology can be infused into science missions without further technology development or validation;

- Schedules and milestones for technology development and validation;
- Data records for each technology;
- Data analysis plans;
- Dependencies with other technologies;
- Success criteria for ground, pre-flight, and flight development and validation segments;
- A plan for technology infusion including:
  - Participation by the project, provider, user, and Program Office;
  - Methods to capture knowledge for technology development and validation and to transfer the technology to U.S. industry and users;
  - Approach for maintaining a database of technology readiness during and at the conclusion of technology maturation that can be used in user procurements; and,
  - A schedule for documentation.

5.1.2.2 Education and Public Outreach Plan

The E&PO Plan shall include the following:

- The requirements for outreach support from the NMP Office such as feeding into existing programs, partners, and alliances and dissemination of E&PO products and material;
- A phased schedule of activities and products;
- A description of the project's independent E&PO efforts such as memorabilia, models, presentation materials, activities during launch events); and,
- A description of the division of responsibilities between the project and the NMP Office that support the NMP E&PO goals defined in paragraph 5.3.

5.1.3 Cost Caps

Each NMP project shall develop projected costs during Formulation Refinement and present them for assessment and review at the CRA, the CR, and project approval. The EAA shall establish the cost cap for each project at project approval, and the cost cap shall be included in the PLRs. The projected costs and the cost cap shall include the full life-cycle cost for implementation which includes development of the flight articles, launch or access to space as a secondary payload, flight technology validation, data collection and analysis, data dissemination, and archiving, E&PO, and reserves. The detailed project budget shall be documented in the Project Plan. Expenditure of project reserves that exceeds the approved reserve usage schedule in the Project Plan shall require approval of the NMP Manager with concurrence of the GPMC and the NASA Headquarters Program Executive.

5.1.4 System Safety and Mission Success

All NMP projects shall be developed and operated within the framework governed by the ISO 9001-quality management system. The mission assurance requirements shall be tailored to each project and implemented as part of the project's risk management activity. The project plan for risk management shall also address the processes for achieving its safety and mission assurance requirements including systems safety, reliability engineering, electronic and mechanical parts reliability, hardware and software quality assurance, oversight of any development processes, problem failure reporting and corrective action, environmental design, and test requirements.

NMP projects should plan to utilize the resources of the implementing center's safety and mission assurance organization, processes, and procedures to develop, plan, implement, conduct oversight, and document its system safety and mission assurance activities (see paragraph 14.2). Projects shall implement the system safety plan throughout the Implementation Phase. When a prime contractor is selected for total system integration, the plan shall address the delegated system safety and mission assurance responsibilities of the providers for the spacecraft system, instrument provider, and/or technology provider. Each project shall also implement system safety processes that meet the requirements of the launch vehicle provider or primary payload provider, as appropriate, at all hardware processing sites and the launch site. Flight validation technologies that are flown on a partnership project other than a dedicated NMP project shall also conform to the system safety requirements of the host project.

5.1.5 Environmental Requirements

All NMP projects shall conform to NASA and U.S. environmental requirements for mishaps, orbital debris, radiation sources, or other environmental concerns. For this purpose, the NMP has an approved, program-level National Environmental Policy Act (NEPA) of 1969 as amended compliance document.[6] The NEPA compliance document establishes boundaries for applications to projects. Projects should endeavor to utilize the Program NEPA document. Each project shall apply the process described in Chapter 6 of the NMP NEPA document to assess whether the existing NEPA document is applicable to that project. If it is not applicable, then the project shall develop a project-specific NEPA compliance document. If it is applicable, the NASA Program Executive shall coordinate the approval of the Project Environmental Impact Statement with the NASA Office of External Affairs, and obtain concurrence from the EAA.

5.1.6 Program Emergency Planning

In accordance with NASA Policy Directive 8710.1 NASA Emergency Preparedness Program Policy, each NMP project shall obtain concurrence of the center emergency preparedness office and provide a Contingency Plan, when appropriate, for EAA approval not later than 6 months before launch.

5.1.7 Success Criteria

Success criteria for a NMP project shall be defined in the PLRs in terms of minimum requirements, fully successful requirements, and goals. Successful validation of project-defining and project-enhancing technologies selected for their first validations on NMP projects is a principal requirement for project success. Goals are additional activities conducted by the project that add value to the project but are not required to be satisfied to achieve a successful project. The metrics for measuring success are established in the Technology Validation and Infusion Plan (see paragraph 5.1.2.1).

5.1.8 Lessons Learned

The NMP Office shall develop "lessons learned" that address the efficacy of its processes. The "lessons learned" will be used to improve Program processes and for guidance to projects in planning formulation and implementation activities.

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[6] NASA, New Millennium Program Programmatic Environmental Assessment, Jet Propulsion Laboratory Document JPL D-14472, June 1998.

Each NMP project shall document "lessons learned" throughout their life cycles. "Lessons learned" that have a potential impact on systems safety shall be submitted to NASA's Lessons Learned Information System (LLIS). Each Project shall submit its final "lessons learned" to the LLIS within six months following completion of the technology flight validation activities.

5.1.9 Project Education and Public Outreach

Each NMP project shall conduct E&PO activities in accordance with its E&PO Plan (see paragraph 5.1.2.2). These activities shall be developed as an integral part of the NMP Office E&PO Plan, feeding into existing NMP E&PO partnerships whenever possible. Project support may include a commitment of funding and engineering expertise. The E&PO activities shall be technology-based rather than science-based. Costs for E&PO activities shall be phased across the project life cycle.

5.2 Requirements for Project Approval

Each NMP project shall proceed into the Implementation Phase only after the project has obtained approval from the EAA. Projects shall satisfy the following criteria to obtain approval:

- The draft PLRs have been approved;
- The preliminary Project Plan conforms to the requirements defined in this document;
- The selected technologies for the project have achieved technology maturity beyond a technology readiness level (TRL) of 5 (component and/or breadboard validated in a relevant environment);
- Technology readiness assessment gates have been defined and scheduled for each technology included in the project;
- A Project Technologist serves on the project implementation team;
- Solicitation and selection of the industry spacecraft partner, testbed provider, or instrument integrator have been completed, where applicable;
- Where appropriate, science participation via an Announcement of Opportunity or NRA has been obtained;
- A confirmed access to space as part of the project baseline has been explicitly approved by NASA Headquarters where appropriate;
- A cost estimate-to-complete has been assessed in a CRA and a CR to ensure that the budget, schedule, and technical performance assumptions and margins are adequate, attainable, and consistent with the commitments and constraints in the NMP PCA;
- Resource control systems are in place to review and measure resource expenditure versus the plan;
- A NEPA Notice or NEPA compliance assessment has been made;
- A successful CRA and CR has been performed;
- A draft Press Release to be issued by the applicable EAA upon completion of Approval is available; and,
- The project's implementing center PMC and NMP GPMC have reviewed the project status, the results from the Project CRA, and concurred with CRA's recommendations to proceed into the Implementation Phase.

5.3 Program Education and Public Outreach

The NMP's E&PO goals for education and public outreach are to:

- Encourage use and translation of NMP generated information for broad educational and public benefit;
- Promote a broad understanding of and interest in technology for space exploration in the general public and in educators; and,
- Advocate the importance and relevance of future space and Earth science missions that will benefit from the technologies validated by the NMP.

These goals account for the unique aspects of the NMP and conform to other NASA strategic and implementation plans for E&PO.

The NMP Office has established and implemented a Program-level E&PO Plan to inspire, inform, and educate the public about the benefits of the technology development and validation results. Along with broader efforts to reach the general public, the NMP shall:

- Design special educational products for science and technology enthusiasts;
- Engage children's organizations, professional education associations, and museum networks; and,
- Create innovative approaches to involve other targeted segments of the public.

The NMP Office shall work with its projects to assure the Program's and projects' E&PO activities and plans are aligned and focussed on common themes consistent with the Program's E&PO goals and to maximize the use of existing alliances.

6.0 PROGRAM SCHEDULE

The NMP PCA defines major milestones for NMP projects in implementation. The EAA established these milestones at project approval; they are documented in the PLRs. Major milestones for NMP projects in formulation shall be proposed first at down-selection for Formulation Refinement and finalized for implementation at project approval.

The NMP Office and its projects shall establish major milestones including the following tasks and reviews with the SSE and ESE:

- Annual SSE and ESE updates of the NMP Office task plans;
- All planned program and project reviews (except monthly reviews) in paragraph 17.0 and 17.1; and,
- The major milestones in Table 6.0-1.

Major Milestones	Description
First and Last Technology Delivery	The delivery of the first and last instrument or technology.
System Integration & Test Start	Mating of the first instrument or technology with the bus.
Spacecraft/Ground System Basic Command & Telemetry Test	Basic command and telemetry test between the bus and ground system.

Flight System End-to-End Data Flow Test	End-to-end test at the flight system and ground system level and includes data flow, dress rehearsals, and simulations.
Launch Readiness Date	The launch date.
Flight system Checkout Complete	On-orbit verification of satellite operation.
Distribution of Validation Results	First distribution of technology/science data products for technology/science validation use.

Table 6.0-1. Major Project Milestones.

7.0 PROGRAM RESOURCES

The NMP cost commitments are established in the NMP PCA. The total cost for implementation of each NMP project and the phasing of project funding are established at project approval. The NMP Office shall propose sub-allocations in the NMP budget for each fiscal year for future projects, projects in formulation, and Program Office activities via the annual Program Operating Plan (POP) submittal to the applicable Enterprise. The NMP Office may also propose re-phasing of funds for projects in implementation in coordination with the project's implementing center as long as the project's cost cap established in the PLRs is not exceeded. Approval of the applicable Enterprise's Operating Plan and the issuance of the New Obligation Authority to the NMP and its projects indicate approval of the NMP budget.

The NMP Office is funded separately from the individual projects. Program Office funding covers the salary expenses for the program staff, the identification of flight validation technology candidates, the Concept Definition phase of Formulation, travel, services, E&PO, and supplies. The funding for the NMP Office in the PCA is separated into individual Task Plans (SSE and ESE), approved by the respective NMP Program Executives, and submitted to the NASA Management Office-JPL for assignment and authority to place funds on the NASA Prime Contract with the California Institute of Technology.

Each project shall include, within its cost cap, sufficient schedule and financial reserves to meet its PLRs.

7.1 Program Resource Control

During Formulation, the project cost estimates are derived from a combination of estimating techniques that include a grass-root estimate and an Independent Cost Estimate. These multiple estimating techniques shall be used to evaluate the adequacy of the projects' funding requests, reserves, and margins and will be reviewed in the CRA and CR.

During Implementation, projects shall provide updates to their latest cost estimate-to-complete in accordance with the review schedule requirements of paragraph 6.0. Deviations from the reserve application plan shall require approval of the NMP Manager and concurrence by the implementing center PMC, the GPMC, and the applicable Enterprise. In accordance with the NMP PCA, projects are subject to a Termination Review if the estimated schedule milestones or cost-to-complete that exceeds the firm cost cap by 15 percent. Cost or schedule increases that are completely beyond the control of the project may be an exception to the need for a Termination Review. They could result in

an increase to the cost cap or change in the schedule milestone subject to the recommendation of the applicable EAA and documented in approved changes to the NMP PCA and PLRs.

8.0 PROGRAM CONTROL

The NMP Office and its projects shall implement program control in accordance with the requirements of NPG 7120.5A and shall implement a configuration management (CM) change process to document changes to requirements, resources, approved plans, and reserves.

9.0 RELATIONSHIPS TO OTHER PROGRAMS AND AGREEMENTS

In accordance with the NMP PCA, agreements are signed between the NMP projects and non-NMP organizations to document support for the NMP projects. Non-NMP NASA organizations and JPL are referred to as internal organizations. Non-NASA and non-JPL organizations are referred to as external organizations. Internal and external agreements shall be included in the PLRs for each project.

9.1 NASA Internal Agreements

9.1.1 Technology Providers

Early in Formulation Refinement, the NMP project shall establish a written agreement with each technology provider from a NASA Center or JPL when a NASA Center has technology selected for the flight validation project. These agreements will be forwarded as part of the draft PLRs submitted for project approval.

9.1.2 Other Support

The NMP project shall establish written agreements between itself and non-NMP NASA organizations (e.g., Space Operations Management Office (SOMO) Project Service Level Agreements) when the non-NMP NASA organization is required for project success. These agreements shall be forwarded as part of the draft PLRs submitted for project approval or to the EAA as a recommended update to the PLRs if they are available after project approval.

9.2 NASA External Agreements

9.2.1 Technology Providers

Early in Formulation Refinement, the NMP project shall establish a draft written agreement with each non-NASA government organizations when the organization has technology selected for a flight validation project. The draft agreements shall be forwarded as part of the draft PLRs submitted for project approval and approved as part of project approval if available. If they are available for project approval, they shall be submitted to the EAA for approval and as a recommended update to the PLRs.

9.2.2 Other Support

In coordination with the Enterprise Program Executive, the NMP project shall develop a draft written agreement with each non-NASA or non-JPL government organization when the capabilities of the non-NASA government organization are required for project success. The draft agreements shall be forwarded as part of the draft PLRs submitted for project approval and approved as part of the project

approval if available. If they are available after project approval, they shall be submitted to the EAA for approval and as a recommended update to the PLRs.

9.3 Access to Space

The NMP encourages a wide variety of methods for access to space. For example, the domestic Expendable Launch Vehicles (ELVs), the Space Shuttle, and interagency collaborative opportunities using spacecraft or launch opportunities from other NASA programs or other Agency programs are options to increase the program flexibility, reduce cost, and maximize flight opportunities.

9.3.1 Space Shuttle

NMP flight technology validation missions may be flown as Space Shuttle deployable payloads only if use of the Shuttle's unique capabilities is necessary for project success. Each NMP project examining the feasibility of utilizing the Shuttle shall coordinate with the Johnson Space Center (JSC) Space Shuttle Program Office during Formulation Refinement to determine whether the NMP project is an acceptable candidate to the Shuttle Program. If the NMP project is suitable, it shall submit a NASA Form 1628, Request for Space Shuttle Flight Assignment, as part of its required documentation for project approval. The applicable Enterprise advocates the request to the Shuttle Program.

9.3.2 Expendable Launch Vehicles

The Kennedy Space Center (KSC) is the Lead Center for the acquisition and management of ELV launch services. Each NMP project planning to use an ELV shall coordinate with KSC through the NMP Office and the Enterprise Program Executive to interface with U.S. launch service providers or to obtain manifesting as a primary, co-manifested, or secondary payload on an ELV.

9.3.3 Interagency Collaboration Opportunities

The NMP shall seek partnering relationships with other government agencies to provide more frequent cost-effective opportunities for flight validating technology in space.

9.3.4 Space Operations Management Office

The SOMO at the JSC oversees and manages space operations and systems for NASA. This includes the Deep Space Network, mission and network control functions, data processing and planning systems, and telecommunications systems. The requirements and interfaces between the NMP projects and SOMO shall be defined separately for each project and documented in an internal agreement called a Project Service Level Agreement that is approved at project approval. The project support from SOMO shall be described in the Project Plan.

10.0 ACQUISITION STRATEGY

10.1 Approach

The acquisition strategy NMP projects shall be as defined in paragraph 4.4.1 through 4.4.5.

10.2 Roles and Responsibilities

The NMP Manager shall lead the overall Program acquisition process for soliciting technology providers selection and Concept Definition. He coordinates the preparation and execution of NMP

solicitations for technology providers, provides draft documentation to the ESE to support the ESE's NRAs for innovative measurement concepts and instruments, and provides funding for Concept Definition studies. The NMP project manager shall lead the acquisitions for the project during Formulation Refinement and Implementation.

10.3 Acquisition Integration

The NMP and projects shall engage their respective acquisition services organization early in project formulation to plan for and accommodate differences between the NMP and its projects in applying Federal Acquisition Regulations, public law, and other institutional procurement procedures that form the legal basis for contract award.

10.4 Oversight

Contractor selection and contract performance assessment against schedule milestones shall be reported at reviews for each NMP project.

11.0 COMMERCIALIZATION OPPORTUNITIES

There may be commercialization opportunities for exploitation by organizations developing new technology for the NMP. When this is the case, the NMP encourages industrial technology providers to create the rationale and opportunities for the commercialization of NMP technology products.

12.0 TECHNOLOGY ASSESSMENT

Technology assessment is a continuous process within the NMP to identify the technologies that need to be flight validated, determine technology readiness, understand risks, and facilitate the infusion of the flight validated technologies. Paragraph 4.4 describes the NMP process for technology assessment.

Changes in project technology developments that adversely affect project schedule, exceed cost cap limits, or that fail to meet maturity (technology readiness gates) requirements will be considered for elimination from the project.

13.0 DATA MANAGEMENT AND ARCHIVE

NMP technology development and validation data are vital data for infusing technology into future science missions, thereby enabling the implementation of the SSE and ESE strategic plans. Therefore, the NMP shall retain and manage the NMP technology development and validation data for NASA. Accordingly, the NMP will establish and maintain a Technology Validation Database that may include information about technology development activity external to NASA. This database will include an archive and standards for NMP-generated raw engineering data and releasable information for access by the customer community of the NMP technology development. NMP projects shall prepare a Technology Data Management Plan that is appended to the Project Plan and approved by the NMP Manager. It shall describe how data will be acquired, be controlled, protects proprietary rights, be stored, and be archived.

The flight environment of NMP technology flight validation projects may present opportunities for collection of secondary valuable scientific data. Where appropriate, each project shall also prepare a

Science Data Management Plan appended to the Project Plan for approval by the Program Manager when project goals for science data acquisition are included in the PLRs.

Project-level documentation and data control shall be managed in accordance with the Project Plan.

14.0 RISK MANAGEMENT

As stated in the NMP PCA, "the high risk areas are the new technologies selected for their first validations on New Millennium projects." A major criterion for project success is the successful flight validation of these high-risk, high-payoff technologies. The NMP imposes a comprehensive risk management program on its projects to assess and manage risk. Project risk management approaches may include processes that are different from those used for science missions to fulfil the project technology development and validation objectives. The NMP adheres to practices that prevent injury to the public, NASA flight crews, NASA employees, and loss of high-value hardware.

14.1 Overview

The NMP risk management is a continuous process involving both Program and project teams. The Program initiates risk assessment when it identifies candidate technologies for flight validation by assigning each candidate a set of flight validation factors for risk reduction (e.g., technology readiness, schedule risk, development cost risk, and performance expectation of revolutionary technology). The NMP divides the risk into two categories, technology user risk and project implementation risks. Technology user risk is risk associated with infusing the technology into science missions—the perceived risk to the first user in a future mission in the SSE or ESE strategic roadmap. Project implementation risk is risk associated with system safety and mission success criteria for the project as established in the PLRs. These latter risks are the high-risk areas having high probability and high impact/severity as defined in NMP 7120.5A, paragraph 4.2. The NMP risk management may also apply to achieving science goals when science goals are specified in the PLRs.

14.2 Risk Management Organization and Responsibility Guidelines

The roles and responsibilities for conducting risk management transition from Program-centric to project-centric as a validation concept transitions from Concept Definition to Formulation Refinement. Before the EAA authorizes concept definition, risk management is led by the NMP Office. The Program Manager assisted by the Program Office staff develops technology validation roadmaps. Each technology in the roadmap is assigned technology user risks and factors for risk reduction corresponding to the intended uses of the technology in science missions. This information is presented to the EAA as part of the information to support the authorization to initiate pre-concept definition and used in the competitive solicitation for technology providers.

During concept definition, each project candidate conducts activities that validate the technology readiness level of each technology and identifies the requirements needed to mitigate the project implementation risks. The concept definition report defines an initial set of procedures and schedules that will be followed during the project life cycle to reduce both the technology user and project implementation risks. The procedures and schedules are reviewed and approved as part of the project approval.

During Formulation Refinement, the project manager takes over responsibility for the project risk management from the NMP Manager. The project's risk management team (e.g., systems engineering, technologists, safety and mission assurance manager, test engineering) supported by technology providers and the industry partner perform continuous risk management throughout the remainder of the project life cycle.

The project implementing center's safety and mission assurance organization is as an integral part of the NMP risk management organizational structure. Therefore, each NMP project should fully utilize its center's safety and mission assurance capabilities including safety and risk management personnel, review expertise, policies, processes, design principles, procedures, reporting systems, tools, training, and lessons learned.

14.3 NMP Risk Management Process

The risk management process for the NMP and its projects shall conform to the requirements of NPG 7120.5, paragraph 4.2 for risk management (e.g., identify, analyze, plan, track, decision-making, control, mitigate, and communicate). Projects shall integrate their technology providers and industrial partners activities into the project's risk management planning and reporting. Each NMP project may tailor its risk management approach to address the unique challenges of its objectives and success criteria specified in its PLRs. Specific project tailoring shall be described in the Project Plan.

14.3.1 Risk Planning

Projects shall use the following Program risk management requirements to formulate and implement the flight validation projects:

- NMP system projects shall not require that flight-proven technologies be flown as part of the flight system to serve as backup to the breakthrough technologies being validated in the projects except when there is determined to be an unacceptable risk to system safety or mission success. This requirement is subject to the following conditions:

    - The risks for breakthrough technologies that serve as critical functions for the spacecraft are explicitly identified, understood, and appropriately mitigated. The rationale and risk mitigation approach to such critical items shall be described in the Concept Definition report, documented in the project's plan for risk management, and reviewed at the CR.

    - The result of coupling project-defining technologies shall be verified. When one project-defining technology is critically dependent on the successful operation of another project-defining technology, the benefits of using such an approach shall be assessed and adequate resources provided to mitigate the associated risks.

    - Cost-effective risk avoidance practices shall be employed in the project design, including all portions of the project that are in support of the project-defining technology validation objectives.

- The project shall conduct a peer review of the technology readiness during the Implementation Phase as a discrete element of the project review process.

- Projects shall plan to implement risk management trades between PLRs only after receiving documented approval from the EAA.
- Projects shall plan a risk management strategy that includes the requirements and milestones to retire unacceptable risks as a function of schedule margin analysis.

14.3.2 Risk Identification and Assessment

Risk identification and assessment becomes a continuous risk management function in accordance with the requirements of NMP 7120.5A, paragraph 4.2, and the project implementing center's procedures for risk management after the EAA authorizes Formulation Refinement.

Each high-risk technology selected for flight validation shall have its technology readiness level no lower than 4 (component and/or breadboard validated in a laboratory environment) at the time of selection for a project. The technology user risks pass from the NMP Office to the project at down-selection and are tracked throughout the remainder of the project's life cycle. Each technology that is a candidate for inclusion in a project shall have a technology readiness level of not lower than the end of 5 (component and/or breadboard validated in a relevant environment) at the time of project approval. The project's approach to risk management including the adequacy of resources and margins to perform the management is reviewed as part of the CR, approved at project approval, and documented in the Project Plan.

Each NMP project shall utilize quantitative and qualitative tools and metrics (e.g., Failure Mode and Effect Analysis, Fault Tree Analysis, and Probabilistic Risk Assessment) in its risk management.

14.3.3 Risk Tracking, Decision-Making, and Control

Program-level risk tracking shall be measured primarily against Program resource constraints, ability to meet the technical performance commitments in paragraph 2.0, and meeting user technology capability needs.

The risk management requiring Program-level decision-making and control shall include but is not limited to the following:

- Adequacy and timeliness of Program and project funding;
- Threat or actual failure to flight validate a technology flight validation item;
- Development of criteria for determining the readiness of the technology for flight validation;
- Factors that threaten achievement of the Program commitments;
- Aggregate of project risk mitigation needs that exceeds reserves and margins;
- Recommendations for descoping or de-manifesting technology included in a project when it fails to meet requirements or is no longer needed for future science missions; and,
- Loss of the implementing center's, industry partner's, or technology provider's capability to support the NMP commitments.

The Project Manager makes the decisions for risk management for a project that do not affect the PLRs, and the NMP Manager concurs with these decisions. The applicable EAA approves changes that change the PLRs.

The project's methods for risk tracking shall be described in the risk management portion of the Project Plan. The project's risk management approach shall include methods for closing out all "primary" risk items prior to delivery for launch.

14.3.4 Communications and Reporting

The status of Program risk management shall be reported regularly at Program reviews and at other times if the Program Manager determines that significant threats or benefits from technology development will change the Program's progress toward meeting its commitments. The Program status will address the Program's progress in meeting its performance commitments and assess the overall progress of NMP projects.

The status of the project risk management including margins and reserves shall be reported throughout the project life cycle as a standard part of the monthly reports, at reviews, and when a significant event threatens achieving the PLRs. Reporting content shall be established in accordance with the Project Plan and its risk management plan.

14.4 NMP Risk Mitigation Requirements and Guidelines

The risk management portion of the Project Plan shall address how cost and schedule reserves will be applied to close out the risk items. Factors such as performance requirements, success criteria, and potential backup technology options (should the technologies selected for flight validation not be available for launch) shall be included.

During Formulation Refinement, each project shall establish a margin and reserve usage schedule to ensure that reserve amortization is appropriately allocated and can be monitored. Reserve and margin guidelines for NMP projects are a 30% cost reserve and a 20% schedule margin at the start of the Implementation Phase. Spacecraft resources shall also be included in the margin and reserve planning unless so designated. Each NMP project shall document this usage schedule in the Project Plan. The funded schedule margin shall be included in the project cost cap. The status of cost reserves and schedule margins (plans versus actual expenditures) shall be reported at regular project reviews.

The Project Plan shall include descope options and decisions points to accommodate project risks. The use of any descope options that impact the technology flight validation and/or the hardware/software configuration shall occur only after completion of the project's configuration control change process. The use of descopes up to the PLRs shall require the concurrence of the NMP Manager. The use of descopes that result in changes to the PLRs shall be approved by the applicable EAA. The status of descope options shall be reported at scheduled reviews.

14.5 Resources and Schedule

Each NMP project shall describe the resources allocated to implement its risk management processes in the risk management plan. The description shall include milestones for descope decisions and schedules for the use of reserves.

14.6 Documentation

Each NMP project shall describe the methods for recording identified risks, reporting risk status at reviews, retaining risk management records, and controlling risk in its risk management plan. Program and project risk information shall be electronically accessible to the NMP Office and the applicable Enterprise.

15.0 LOGISTICS

Transportation of flight articles, support equipment, and support personnel are project-unique and shall be addressed in the Project Plan.

16.0 TEST AND VERIFICATION

The project's test and verification plans for technology flight validation products and other flight articles shall be described in the Project Plan. Thorough test and verification throughout the technology development, integration with the flight system, and performance in space shall be an integral part of the project's technology flight validation and risk reduction plans. A project should plan to utilize its implementing center's processes and procedures to conduct its test and verification activities. The status of test and verification activities shall be presented at each review.

17.0 REVIEWS

The GPMC shall review the NMP at the Program and project level in accordance the schedule provided in Table 17.0-1, NMP Reviews.

In accordance with the NMP PCA, the GPMC at the JPL has been delegated the responsibility to ensure the independent review of the NMP and its projects. It has a policy and established procedures to provide the equivalent of a Non-Advocate Review (NAR) prior to the advancement of projects to succeeding segments of formulation and implementation.

Program Reviews			
Type	**Purpose**	**Timing**	**Review Activity**
POP Review	Combines both Program and project's operating plans submittal to the SSE and ESE as part of NASA's budget planning for the coming fiscal year.	Annually; NMP Manager briefs Enterprises prior to submittal	ESE, SSE
Annual Review	Program status: description of potential future focuses for projects, ongoing project development activities, and performance against metrics and commitments in the PCA and this Program Plan.	Coincident with POP cycle	ESE, SSE
Program Quarterly Reviews	Evaluation of the Program status: PCA; summary of any tailoring to NPD 7120.4 and NPG 7120.5; Program architecture; Program Plan; changes in goals and objectives; progress in meeting performance metrics and Program commitments; Program risk assessment; and external requirements.	Quarterly	GPMC, ESE, SSE
Enterprise Monthly Reviews	Provide Program/project highlights.	Monthly	GPMC, SSE, ESE

Table 17.0-1. NMP Reviews.

17.1 NMP Project Reviews

Each NMP project shall conform to the review requirements given in Table 17.1-1. These review requirements may be tailored for each Enterprise depending upon the technology flight validation objectives and the project's size, cost, complexity, visibility, and degree of risk. Project-specific review and reporting requirements shall be described in the Project Plan. Project reviews may be conducted in accordance with the implementing center's guidelines for project reviews.

The NMP shall conduct a kick-off review with each project shortly after technology providers are selected. Prior to the CR, the NMP Manager shall form an independent review panel to determine the project's readiness for confirmation. Results of the independent review are presented to the GPMC as a part of each project's CRA. If the CRA is successful, the GPMC provides a written recommendation to the applicable EAA that the project is ready to advance to the implementation phase. The EAA reviews the project's plans, documentation, and results of the independent review and either approves the project for implementation, directs that project formulation continue, or cancels the project.

Type	Description	Timing	Review Activity
Kick-off Review	Align Program and project implementation planning activities and expectations; establish communications; review lessons learned; establish roles and responsibilities; establish project planning requirements.	After technology provider selection	NMP, ESE or SSE
System Requirements Review	Determine the completeness, consistency, and ability of the requirements to fulfill the stated technology flight validation objectives.	One month after the beginning of Formulation Refinement	NMP
Technology Readiness Review (1)	Determine that the technologies for flight validation have matured to the end of TRL 5 (Component and/or breadboard tested in a relevant environment) and are ready for implementation.	Prior to CR	NMP
Preliminary Design Review (PDR)(1) Mission Design Review (2)	Review the design at about 10 percent drawings against the requirements to evaluate the readiness of the project to proceed with detailed design. An ESE review that combines the PDR and CDR when the PDR and CDR are not held as separate reviews and is required before producing flight hardware. (2)	Prior to CR	Implementing Center PMC
Confirmation Readiness Assessment (CRA)	Determine the project's readiness to advance to the implementation phase by establishing that the design meets the technology validation objectives, the management processes are sufficient to implement the project, and the resources are sufficient to complete launch and operations on time and within the budget.	Prior to CR	Implementing Center PMC, GPMC, NMP Office, Independent Review Panel
Confirmation Review (CR) and Project Approval	Review the results of the CRA and approve the project to start the implementation phase.	Following a successful CRA	EAA

Table 17.1-1. NMP Project Review Requirements.

(1) May be combined (2) Applies to ESE projects only

Type	Description	Timing	Review Activity
Critical Design Review[1]	Evaluate the readiness of the project to proceed with fabrication, assembly, integration, and test at completion of 90 percent of the drawings. Determine that risk retirement is in accordance with plan presented at project approval.	PLRs schedule	Per Project Plan
Pre-Environmental Review	Evaluate the readiness of the product to be tested and the adequacy of the test procedures, test equipment, and test facilities.	Following final assembly of the flight system; PLRs schedule	Per Project Plan
Pre-Ship Review	Evaluate the readiness of the product, equipment, support personnel and facilities for delivery to the launch site or customer and approve the shipping of flight articles.	Prior to delivery of hardware to launch site or customer; PLRs schedule	Per Project Plan
Launch Readiness Review/ Mission Readiness Review[2]	Evaluate the readiness of the flight systems, ground system, supporting facilities, and operations personnel to support the launch.	Prior to launch; PLRs schedule	Per Project Plan
Flight Validation Readiness Review/ Mission Operations Review [2]	Evaluate the readiness of all systems, flight validation technologies, supporting facilities, operations procedures, and operations personnel to safely conduct the operations phase of the project.	Prior to launch; PLRs schedule	Per Project Plan
Monthly Management Reviews	To assess progress against planned objectives.	Monthly	NMP

Table 17.1-1. NMP Project Review Requirements (Continued).

(2) May be combined (2) Applies to ESE projects only

18.0 TERMINATION REVIEW CRITERIA

Exceeding the parameters or levels specified in Table 18.0-1 will result in GPMC considerations for a Termination Review and or NMP demanifest of a flight validation technology.

Parameter	Termination Criteria
Cost	Forecasted cost-to-complete exceeds the cost cap
Schedule	Loss of schedule margin including funding that seriously threatens attainment of project technology validation objectives
Technical Performance	High probability that primary flight validation objectives will not be met
Technology Readiness	Technologies not expected to be ready for integration with the spacecraft, when required, and the PLRs can not be met
Risk Retirement	There are primary risks that will not be retired

Table 18.0-1, Termination Review Criteria

19.0 TAILORING

The NMP PCA defines the tailoring of the requirements of NPG 7120.5 for the NMP as follows:

19.1 Formulation Phase

The NMP divides the Formulation Phase for each project into two or more segments. More than one concept may be approved to start Formulation. Positive results of reviews and Headquarters' approval of the results of the reviews are required to advance to succeeding segments.

19.2 Reviews and Approval

A review that confirms the commitment to move into the Implementation Phase, the CR, is conducted instead of a NAR.

19.3 Project Operations and Capture Process Knowledge

The NMP coordination activities described in this document promote the infusion of the validated technologies from the NMP projects into customer missions and help to retain customer advocacy. The technology validation and infusion activities for the NMP projects described in this document equate to the combination of the project operations and capture process knowledge requirements of NPG 7120.5.

19.4 Earned Value Management

During the NMP and project Implementation Phases, Methods that provide the equivalent content to Earned Value Management are used to assess technical, cost, and schedule parameters during project and Program execution.

19.5 Training

The NMP makes a commitment to continuous learning and competence in project and program management by permitting substitutions of required courses for experience and by holding program and project managers' line supervisors accountable for annual training requirements.

20.0 CHANGE LOG

This Program Plan is the initial issue and supersede the NMP Plan dated July 7, 1997.

Date	Event	Change	Addendum	Program Manager's Signature	Enterprise Associate Administrators' Signatures

Appendix A - Acronyms

AO	Announcement of Opportunity
CRA	Confirmation Readiness Assessment
CR	Confirmation Review
DS	Deep Space
EAR	Export Administration Regulation
EAA	Enterprise Associate Administrator
ELV	Expendable Launch Vehicle
EO	Earth Observing
E&PO	Education and Public Outreach
ESE	Earth Science Enterprise
ESTO	Earth Science Technology Office
GPMC	Governing Program Management Council
IPFT	Integrated Project Formulation Team
ISO	International Standards Organization
ITAR	International Traffic of Arms Regulation
KSC	Kennedy Space Center
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LLIS	Lessons Learned Information System
MCR	Mission Confirmation Review
NAR	Non-Advocate Review
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NMP	New Millennium Program
NPG	NASA Procedures and Guidelines
NRA	NASA Research Announcement
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PLRs	Project Level-1 Requirements
POP	Program Operating Plan
SESPD	Space and Earth Science Programs Directorate
SOMO	Space Operations Management Office
SSE	Space Science Enterprise
TRL	Technology Readiness Level

Appendix B - NMP Project Level-1 Requirements for Deep Space-1

Deep Space One

Level-1 Requirements and Goals

Pietrowski

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

JAN 13 1997

Reply to Attn of: SD

To: Jet Propulsion Laboratory
Attn: 180-703/Director for Earth and Space
Science Programs

From: S/Deputy Associate Administrator for Space Science

Subject: Level 1 Requirements for New Millennium Deep Space Missions

The Level 1 Requirements for New Millennium missions Deep Space-1 (DS-1) and Deep Space-2 (DS-2) are enclosed. These requirements were reviewed with the DS-1 and DS-2 Project Managers and it my understanding that the New Millennium Program Manager, you, and JPL accept these requirements for implementation of the respective missions within the cost caps and specified schedules.

There shall be no changes to these Level 1 Requirements without my express written approval.

Wesley K. Huckins III
Deputy Associate Administrator
for Space Science

DEEP SPACE ONE LEVEL-1 REQUIREMENTS & GOALS

Requirements

1. Validate the following prime technologies through space flight

   Solar electric propulsion as primary propulsion
   Advanced solar array
   Autonomous navigation as primary navigation
   3-D stack computer as the flight computer
   Miniature imaging camera spectrometer

   It is expected that other advanced technologies vital for 21st century science missions will also be validated on DS1 to the greatest extent possible within the approved funding (see goals below).

2. Launch by the end of July 1998

3. Obtain validation data for the technologies demonstrated on DS1 within 2 years of launch.

4. Complete the Project within a Project cost cap of $138.5M. This cost cap includes funding from the Office of Space Science, the Office of Space Access and Technology, and all costs for launch services funded by the Expendable Launch Vehicle Program. Contributions from separately funded technology programs, such as NASA's NSTAR and BMDO's SCARLET Programs, are not capped.

Goals

1. Fly by one asteroid and one comet and return images and spectra. Monitor solar wind throughout the mission and measure the interaction of the solar wind with the targets during the flybys.

2. Validate the following additional technologies through space flight:

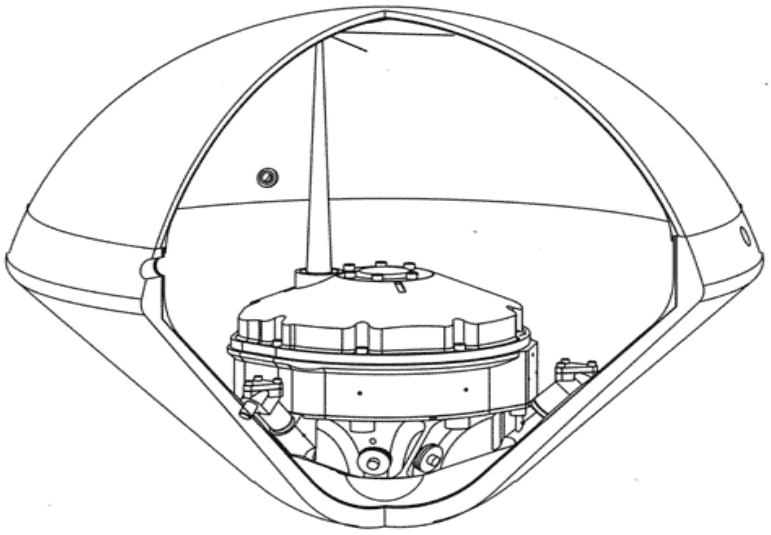
   - Small deep-space transponder
   - Autonomy - remote agent architecture
   - Miniature ion and electron spectrometer
   - Autonomy - beacon monitor operations
   - Ka-band solid state power amplifier
   - Low power electronics experiment
   - Multi-functional structure
   - Power actuation and switching module

Prepared by: _____
David H. Lehman, Flight Team Manager
Deep Space One

Approved: _____
E. Kane Casani, Program Manager
New Millennium Program

Concurred: _____
David A. Gilman, Program Executive
Office of Space Science
Mission & Payload Development Division

Appendix C - NMP Project Level-1 Requirements for Deep Space-2



Project Plan, Section 2.0
Project Objectives, Requirements, Constraints, and Success Criteria

Piotrowski

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

JAN 13 1997

Reply to Attn of: SD

To: Jet Propulsion Laboratory
Attn: 180-703/Director for Earth and Space
Science Programs

From: S/Deputy Associate Administrator for Space Science

Subject: Level 1 Requirements for New Millennium Deep Space Missions

The Level 1 Requirements for New Millennium missions Deep Space-1 (DS-1) and Deep Space-2 (DS-2) are enclosed. These requirements were reviewed with the DS-1 and DS-2 Project Managers and it my understanding that the New Millennium Program Manager, you, and JPL accept these requirements for implementation of the respective missions within the cost caps and specified schedules.

There shall be no changes to these Level 1 Requirements without my express written approval.

Wesley R. Huckins III
Deputy Associate Administrator
for Space Science

New Millennium Program
Deep Space Two
Level-1 Requirements

December 12, 1996

Requirements

Develop and validate the following highly integrated systems and technologies required to deliver multiple microprobes (< 10 kg each) to the surface and subsurface of Mars using a direct entry:

Microtelecommunications system with programmable transceiver
Power microelectronics
Advanced micrcontroller
Flexible interconnects for system cabling
Ultra low temperature lithium battery
Meteorological high-g pressure sensor
Advanced subsurface sample collector/soil moisture detector

It is expected that other advanced technologies vital for 21st century science missions will also be validated on DS2 to the greatest extent possible within approved funding.

2. Acquire science data for use by the scientific community using the science technology demonstration instruments. Provide for the archiving of data in the PDS consistent with guidelines for the 1998 Mars Surveyor science data.

3 Launch microprobe(s) in January 1999, as a technology demonstration payload onboard the 1998 Mars Surveyor Lander spacecraft cruise stage.

4. Return data via radio relay through Mars orbiting spacecraft.

5. Acquire validation data for the technologies demonstrated within 2 weeks after Martian impact. Validate and archive science data within 6 months after Martian impact.

6 Complete the Project within a total life-cycle cost cap to NASA of $26.4 M. This cost includes the cost of a solid rocket motor for the 1998 Mars Surveyor Lander Delta launch vehicle, integration of the probe with the Lander, science support, mission operations, and validation and archival of science data. The cost is based on a project start date of 1/1/96, and project completion 6 months after landing.

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109-8099
(818) 354-4321

JPL

July 28, 1998
Ref: DS2/CE - 022

Dr. Wesley T. Huntress
National Aeronautics & Space Administration
HQ5A11-Mail Code S
Washington, DC 20546-0001

Subject: Demanifest of Pressure Sensor from the DS2 Flight

Dear Dr. Huntress,

In the last several months, members of your staff have been briefed on the technical difficulties in the development of the DS2 telecommunications subsystem. At present, the project has adopted a backup approach for the digital portion of the telecommunications subsystem which occupies a larger volume than the original Digital Application Specific Integrated Circuit (ASIC). This necessitates the removal of the DS2 pressure sensor in order to create the necessary space required to accommodate the new design. Because a telecom system is mandatory for minimum mission success, it is recommended that the pressure sensor be deleted as a Level 1 Requirement for DS2. Efforts will be made to seek other flight opportunities for the pressure sensor.

As there are minimal residual calibration activities for the pressure sensors, it is recommended that DS2 complete those activities to facilitate the use of this technology on future science missions. The project will work closely with Headquarters to assess impacts to the DS2 Science Team.

Your approval for deletion of the pressure sensor as a Level 1 Requirement for DS2 is solicited.

Dr. Charles Elachi
Director, Space and Earth Science Programs Directorate

cc: E. Huckins
B. Piotrowski
K. Ledbetter
D. Brewer
J. Lee
P. Ulrich
C. Elachi
F. Li
T. Gavin
G. Parker
M. Landano
S. Gavit
D. Crisp
S. Smrekar
M. Buehler

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

SEP 11 1998

Reply to Attn of

SD

Jet Propulsion Laboratory
Attn: 180-703/Director, Space and Earth Science Programs Directorate

FROM: S/Associate Administrator for Space Science

SUBJECT: Demanifest of Pressure Sensor from Deep Space-2 (DS-2) Flight

Thank you for your letter dated July 28, 1998. Your request to demanifest the Pressure Sensor, a Level I requirement for DS-2, due to the intrusion of the newly redesigned Telecom subsystem into the Pressure Sensor's mounting area, is approved. Deletion of the Pressure Sensor from the manifest is unfortunate since its development and testing have progressed so well, and its readiness for flight was on schedule. However, the developmental problems with the Telecom subsystem, also a Level I requirement and a mandatory element for mission success, necessitated additional mounting area, and removal of the Pressure Sensor is a logical choice.

The New Millennium program (NMP) is recognized as a technology development and an in-flight demonstration program with lofty goals. A major precept of the program is that not all developments for a mission will be totally successful; however, striving for 100 percent success is expected. In this case, I believe that a diligent effort was made to develop a miniaturized "Telecom-on-a-chip" for DS-2, but the lack of schedule flexibility on the launch date did not allow sufficient time to overcome the Telecom system development problems and, thus, maintain both the Telecom system and Pressure Sensor on the baseline manifest.

I agree that the calibration of the Pressure Sensor should be completed and that other flight opportunities should be pursued. However, work on the Pressure Sensor should be secondary to any activities associated with completing DS-2 flight readiness on schedule.

Wesley T. Huntress, Jr.

cc:
S/Dr. E. Huckins
S/Dr. C. Pilcher
SD/Dr. W. Piotrowski
SP/Mr. J. Lee
SR/Dr. M. Meyer